

USE OF FRESH COW'S MILK IN INFANT FEEDING.

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## THE USES OF FRESH COW'S MILK IN INFANT FEEDING.

### I N T R O D U C T I O N.

In discussing any question of infant feeding, it is unnecessary to put forward the prior claims of breast milk in the successful rearing of babies. A glance at any work on Infant Mortality shows that the subject is inextricably bound up with the relation of breast to bottle-feeding.

The ideal food for every infant is breast milk, supplied by its own mother. The best substitute is the milk of a wet-nurse, which is not often obtainable and to the use of which the baby's relatives may have an objection.

Not only has breast milk the correct composition for the human infant, but also it is free from pathogenic organisms and transmits to the infant immunity from infectious diseases.

The milk of every animal is a perfect food only for its own species. Herein lies the difficulty of infant feeding.

The following table gives a comparison of the percentage composition of the milk of different animals with that of a woman.



Animal	Casein- ogen.	Albumin.	Total Protein.	Fat.	Carbo- hydrate	Ash.
Woman	1%	.5%	1.5%	3.5%	7%	.2%
Mare	1.3%	.8%	2.1%	1.1%	5.9%	.36%
Cow	3%	.5%	3.5%	4.	5%	.72%
Goat	2.9%	.9%	3.8%	4.2%	4.6%	.85%
Ass	.8%	1.1%	1.9%	1.4%	6.2%	.47%

From this we see that the nearest approach to human milk is that of the ass. Next come the milk of cows and goats. For economic reasons the milk most used is cow's milk. Having decided to use it, it is essential to consider how it is to be rendered suitable for the needs of the human infant.

Once again, the percentage composition of human and cow's milk is:-

	Casein- ogen.	Albumin.	Total Protein.	Fat.	Carbo- hydrate.	Ash.
Human	1%	.5%	1.5%	3.5%	7%	.2%
Cow	3%	.5%	3.5%	4%	5%	.72%

Bulk for bulk, human and cow's milk have the same caloric value, 20c per oz., so that theoretically an infant ought to thrive as well on one as on the other; but the difference in the quantity and quality of the ingredients provides a problem which requires/



requires careful thought. Feldman<sup>(1a)</sup> says:-

"The question of the proper use of cow's milk in the artificial feeding of infants is ..... a vast battlefield in which every inch of territory has been and is being keenly disputed". The dispute is divided into periods, during each of which a different element in the milk is accused of causing the trouble in successful infant feeding. As in most disputes, no one factor is absolutely right or wrong; but the difficulty lies somewhere between them all. The more one reads and the larger the number of cases one sees, the more firmly is it impressed upon one's mind that artificial feeding with cow's milk is a simple matter for healthy infants with unruffled digestion; but that once tolerance for any particular element is upset, it is almost beyond the ingenuity of man to provide a food which will sustain the infant and also relieve the symptoms.

*unsuccessful?*

*faction?*

?

Cow's milk has been given in many ways, modified according to the beliefs of the experimenter. Briefly they are:-

1./



- ( 1. Whole Milk.
  - (a) Raw
  - (b) Boiled
  - (c) Citrated
  - (d) Peptonized
- A. ( 2. Diluted i.e. humanized.
  - (a) Percentage basis.
  - (b) Caloric "
- ( 3. Acidified.
- ( 4. Condensed.
- B. ( 5. Dried.
- ( 6. Synthetic.

The six groups may be classed in two large sections:-

- A. Fresh cow's milk 1 - 3, in which the milk is used within a limited number of hours after production, and
- B. 4 - 6 in which the milk may have been kept for almost any length of time before use.

Fresh cow's milk has many advantages over condensed, dried or synthetic milks.

It is cheaper than the other varieties. People understand what they are buying and there are no trade instructions issued with it, so that the most ignorant mother can be sure, within limits of what she/



she is buying, and the most gullible is not further entangled in printed instructions which may differ from those of her medical adviser.

I have said that the mother can be sure within limits of what she is buying.

The law demands a minimum standard for milk, 3% fat and 8.5% solids not fat, and in certain cases allows the producer to ask a higher price for milk superior in quality. But, while the superiority consists in comparative freedom from bacteria, the minimum standard takes no account of bacterial contamination, so that a mother may buy a milk which has a high bacterial count and consequently low keeping qualities. This is a point into which I shall look at greater length in the appropriate section.

Of the three methods of presenting fresh cow's milk, none can be called the right or the best for all infants. The needs of each individual baby must be studied separately, and the capabilities of each mother allowed for.

An infant's digestive system must, obviously, be tremendously adaptable, or otherwise no infant could survive the lack of its Mother's milk.

When I was resident at the Royal Maternity and Simpson Memorial Hospital, Edinburgh, I was accustomed to using whole citrated milk when artificial/



artificial feeding was necessary, in even the youngest infants. We had excellent results, i.e. the infants rose to or above their birth weight in ten days, and there were no digestive troubles, probably because the feeds were intelligently given, and because the infants' digestive powers had not been tampered with or upset in any way.

Following these results, on going to the North of England as Assistant M.O.H., I thought I had solved the problem of infant feeding, and then found that what suited one baby was certainly not bound to suit the next.

In three and a half years of infant welfare work, which took me into the people's homes, what impressed me most in the difficulty of infant feeding was, that usually the trouble lay not in the baby or in the food, but in the way the food was given. I am quite sure that a normal infant intelligently fed from the outset will thrive on fresh cow's milk even undiluted; but that trouble arises with infants whose digestion has been upset by previous indiscretions.

Melman<sup>(2)</sup> says " We do not see as many terrible cases of marasmus, scurvy and other cases of mal-nutrition as formerly ..... Is it new ultra scientific methods of feeding? ..... or is it the discovery of a new proprietary or patented food?..... I do not believe/

believe it is either, for a great many infants are still being fed on about the same substitutes as formerly ..... The only factor ..... was the education of the Mother".

Fresh cow's milk is a convenient form of food. The mother understands the substance with which she is dealing. She knows that liquid milk must be used fresh and there is no difficulty with the mixing or measuring of quantities.

Many authorities extol the virtues of one method of modification to the exclusion of all others, every one of which has its own sphere.

In the following sections I intend to survey the vexed question from all stand-points excepting that of peptonization which must always be a purely therapeutic measure.

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## H I S T O R Y.

Artificial feeding was practised as far back as the 9th Century B.C. During the excavations at Nineveh, a relief, dating from this time, was found. It portrays a woman carrying a baby on her shoulders. In her left hand is a feeding bottle. The food used was honey, butter, milk and pap (Cf. Isaiah VII, 14). Another, but more significant relic of ancient days is the discovery, in the old citadel of Aquinum, of an infant's skeleton together with a feeding bottle. Artificial feeding was exceptional, breast feeding either by the mother or a wet nurse, being the rule. During the reign of the Ptolemies 330-43 B.C. foster mothers were under contract to suckle infants for six months, and then to give them the best cow's milk, of which there was a regular daily delivery for another eighteen months <sup>(1b)</sup>.

In India, about the 2nd Century B.C. the writings of Susruta, containing advice on infant hygiene, advocate the use of goat's milk, where breast feeding is impossible, and, if that is not obtainable, cow's milk.

In the 2nd Century A.D., Soranus the Greek physician, wrote a book on antenatal and postnatal hygiene, including a comprehensive section on child hygiene./



hygiene. He devotes most of his advice on infant feeding to the encouragement of breast feeding and to methods of increasing the supply, by regulation of the mother's habits and diet. He mentions artificial feeding from the bottle with an artificial nipple. Feldman<sup>(1c)</sup> quotes a sentence from Soranus' work, Chapter 39. "One must take care not to give the baby any milk between feeds, for when the food (pap etc.) floats on the top of the milk, it is distributed with difficulty throughout the body. Yet, if the baby is very thirsty, one may give it water or diluted wine from an artificial nipple".

Until the 15th and 16th Centuries, knowledge of pediatrics remained at the same level which it had reached in Soranus' days.

At this time artificial feeding became prevalent, the milk of the cow or goat being used. A great many authors began to write books or essays on the subject of infant hygiene, but the idea of artificial feeding does not appear to have been treated seriously. In fact as late as 1774, Underwood in his *Treatise on the Diseases of Children*, speaking of the Esquimaux of Greenland, says "Whenever a suckling mother happens to die, her infant is buried with her ..... It is esteemed an act of compassion to put an end to an infant's suffering (as the result/



result of artificial feeding) by plunging it into the sea".

It was not till 1838 that any scientific work on this important branch of pediatrics was done. In this year, Johann Franz Simon of Berlin made an investigation of the comparative chemical composition of cow's and human milk. This marks the beginning of scientific study of the question of artificial feeding of infants. In 1869, Philip Biedert put forward the theory that indigestion in artificially fed infants was due to the casein in cow's milk, and in the same year, Soxhlet introduced the idea of surgical cleanliness into the hygiene of cowsheds and of milk transportation, thus stimulating thought on two of the important points determining success or failure in artificial feeding.

#### THE INFANT WELFARE MOVEMENT.

Between 1841 and 1870 the Infant Mortality figure and the general death rate were practically stationary, viz. 150 Infant Mortality Figure and 21.5 Death Rate. After the introduction of the Public Health Act in 1875 both declined; But, while the Death Rate declined steadily to 12.5 in 1925, the Infant Mortality Figure fluctuated until the beginning of the 20th Century, when it declined from 138 in the years 1901 - 1905, to 75 in 1925, and/

and this in spite of the fact that the figure for neonatal deaths, i.e. deaths under four weeks, only declined from 40 per 1000 to 32 during the same period. The reduction, then, took place in deaths between one and twelve months. Tables shewing the deaths under one year from 1883-1923 in England and Wales, classified according to cause, shew that the greatest reduction has been effected in deaths from digestive troubles, i.e. diarrhoea and convulsions. The obvious conclusion from this is that there has been improvement in infant feeding and also in the cleanliness of the milk supply.

What were then improvements? In 1869 there came the first practical recognition of the need for modification of cow's milk to meet the requirements of the infant. Indigestion was overcome by diluting the milk with water. Consequently, infants were fed on milk diluted four times, the dilution being gradually decreased.

In 1877, Joseph Forster made <sup>(1b)</sup> exact scientific enquiries into the needs of infants by studying the gaseous metabolism in the new born. He shewed that they produce twice as much  $\text{CO}_2$  per unit of body weight as adults. Further research by Rubner & Heubner culminating in 1898 in a report on food requirements of normal and wasting infants, shewed that metabolism is a function of the surface area./



area. This line of research has been pursued ever since. Notable additions have been made by Talbot from 1914 onwards. He attributes the relatively greater loss of heat by an infant to the greater proportion of active protoplasm in its cells. He estimates the caloric needs as 50 per pound body weight, up to six months, decreasing to 45 at one year. From this it may be seen that mere dilution of the protein element of the milk is not enough, also, that to begin with, a weak mixture and to increase the caloric value is not a physiological process.

#### THE CAMPAIGN FOR THE REDUCTION OF INFANT MORTALITY.

This has three lines of progress:-

- (1) Improvement of the milk supply, governed by various milk regulations. These include such acts as the Contagious Diseases (Animals) Acts 1878 and 1886. Dairies, Cowsheds and Milkshops Orders 1885, 1886 and 1899, all of which have been repeated in favour of:-

The Infectious Diseases Prevention Act 1890.

The Milk and Dairies (Amendment) Act 1922.

The Tuberculosis Order 1925.

and The Milk and Dairies Order 1926.

which/

which Acts are directed towards securing clean production, and the Sale of Food and Drugs Act dating from 1875, amplified in 1879 and 1899, and added to in 1901 by the Sale of milk Regulations, setting the standard of milk at 3% fat and 8.5% solids, not fat, and preventing the use of preservatives.<sup>(3a)</sup>

(2) The Notification of Births Act.

Permissive in 1907 and made compulsory in 1915. This Act further empowered local authorities to formulate schemes for the prevention of Infantile Mortality.

(3) The Maternity and Child Welfare Act, 1918.

Requiring that provision of Schemes for Maternity and Child Welfare should apply in all areas. These schemes included the establishment of infant welfare centres etc.

Briefly the history of infant welfare centres is as follows.

In France, as the first step towards perfecting methods of infant feeding, Variot in 1892, established in Paris, Milk Stations, "gouttes de laits" and Budin opened his "Consultations des Enfants". Every effort was made to secure breast feeding; but when this was found to be impossible, clean milk was distributed/



distributed to necessitous mothers. A milk station was first opened in England, at St Helens in 1899. In 1906, the first School for Mothers was opened in St Pancras. This was followed by the beginning of Infant Consultations in Marylebone in 1907. Gradually these centres became general in most of the large towns; but they were all on a voluntary basis. The principle of these centres was entirely preventive. Advice was given to mothers on feeding etc. and a body of health visitors, attached to the clinics visited the homes to help in carrying out such advice.<sup>(4)</sup>

This campaign for the reduction of Infant Mortality concentrated on (1) the encouragement of breast feeding, and (2) the perfection of methods of artificial feeding. The foundation of this latter was laid on research into the metabolism of infants, mentioned above. Budin used whole cow's milk.<sup>(17)</sup> Following Biedert's theory that indigestion in artificially fed infants was due to the casein of cow's milk, and having due regard to the standard of fat and sugar in breast-milk, Dr Meigs of Philadelphia in 1885 introduced the idea of reducing the protein without cutting down the fat. He allowed milk to stand for the cream to rise, and then used top milk together with added sugar. This is the method made famous by Truby King<sup>(5)</sup>.

T. Morgan Rotch, also an American, went further still./

still. He elaborated a scheme, followed by Ralph Vincent<sup>(6)</sup> in this country, for ordering milk by a prescription stating the exact percentages of each ingredient. Both of these methods aim at "humanization" of cow's milk, and both have enjoyed a vogue when they were looked upon as the only possible way of feeding infants. The next fashion, also hailing from America, was for milk, whole or diluted, to be used acidified. At the present time the pendulum is swinging to the other extreme once more and whole milk has its protagonists. The problem is far from being solved. As Eric Pritchard says<sup>(7)</sup> "Recent development in knowledge of nutrition has rendered it more responsible and difficult".

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HISTORY OF VITAMINES.

The word Vitamine was coined by Casimir Funk, in 1912<sup>(19)</sup>. He found that yeast contained something essential to life and he thought that this essential was an amine akin to the amino acids of protein.

Although these essentials have never been isolated or given any chemical formula it is now known that they are not amines; but the name Vitamin or Vitamine has caught the public eye and no better name has been invented.

So far the existence of four Vitamins has been proved, and a research is being done upon a fifth. They are called A. B. C. D. and E.

VITAMIN A.<sup>(13b)</sup>

In 1906, Gowland Hopkins<sup>(19)</sup> shewed that something else was necessary for growth and development in rats beyond protein, carbohydrates, fats, salts and water, the five gross necessities, and that it could be supplied by adding to the animals' diet a small quantity of fresh milk, although the amount of milk did not materially affect the caloric value of the food.

In 1909, Stepp<sup>(19)</sup> shewed that rats developed normally on bread made with milk; but that they declined rapidly when the bread was extracted with alcohol. Stepp concluded that something more than/

than the five isolated food stuffs was necessary and that this essential was in the nature of a lipoid. Next, research by MacCollum, Osborne and Mendel in 1913<sup>(19)</sup> shewed that an unwholesome diet of isolated foodstuffs, in which fat was represented by lard, could be made wholesome by changing lard to butter fat, and that the resubstitution of lard for butter fat produced loss of weight. They attributed this to a lack of "something" possessed by butter and lacking in lard. These experimenters also shewed that egg yolk, beef fat and cod liver oil could replace butter fat successfully; but that neither olive nor almond oil could do so. Further, they found that by the substitution of butter fat, containing this accessory food factor, for lard which does not, not only does the weight increase, but also the disorder due to its absence, disappears. Moreover, they discovered that the vitamin-negative quality of lard was not due to its production by steaming, as the steaming of butter did not devitalize it.

Vitamin A is called fat soluble because it is usually associated with fatty animal foods. It can be destroyed by prolonged heating in the presence of  $O_2$ , but can be preserved if  $O_2$  is excluded even after being raised to a temperature of  $100^{\circ}C$  for many hours.

It/



It is found in milk and is not destroyed, therefore, by ordinary boiling. Its absence leads to faulty development and an eye disease called Xerophthalmia.

For some time fat was looked upon as the sole source of vitamins, until Funk shewed, 1910-1912, that fat had no power to cure beri-beri.

#### VITAMIN B. (13b)

In 1882, Takaki,<sup>(19a)</sup> Medical Inspector General of the Japanese Navy came to the conclusion that Beri-beri was caused by some deficiency in the diet. Thinking that it was a protein deficiency, he added milk, meat, fish and vegetables to the ordinary rice ration of the sailors and the disease was immediately reduced to nil in those who took the fuller diet.

In 1897, Eijkman,<sup>(19a)</sup> a Dutchman in Java, found that some of his fowls which had been fed on cooked, polished rice, were suffering from polyneuritis, which is the same thing as Beri-beri. He replaced the cooked rice by uncooked, unhusked rice, and the fowls recovered. He followed up this accidental discovery by shewing that polished rice, i.e. rice from which the husk and pericarp have been removed by milling, caused Beri-beri; but that the addition of the millings cured the condition. His view was not accepted and no work was done on this subject for/

for some years.

In 1910-1912 Funk shewed that yeast was rich in Vitamin B. He tried to isolate it and found that 200 lbs. of yeast yielded about  $\frac{1}{12}$  oz. of active substance; but that this was so active as to cure the disease, in pigeons, in a few hours, if  $\frac{1}{15000}$  oz. were added to otherwise satisfactory diet.

Polished rice was known to cause Beri-beri in man and polyneuritis in birds, so MacCollum<sup>(19a)</sup> substituted polished rice for starch and milk sugar in his unwholesome diet mentioned above.<sup>p17</sup> He found that the animals developed Beri-beri, but that if milk sugar were added, they recovered.

He next shewed that purification of the milk sugar gave a product which could no longer cure it; but that addition of the washings was immediately efficacious.

Beri-beri is not seen in this country. Whatever form milk may be taken in prevents the onset of the disease. The vitamin, water soluble, is extremely stable.

#### VITAMIN C.<sup>(13b)</sup>

As early as 1776, Captain Cook, in the Philosophical Transactions, describing the methods taken for preserving the health of the Crew of H.M.S. Resolution, during a voyage round the World, shewed how/



how fresh food, animal or vegetable, was necessary to prevent disease in the crew.

During the latter part of the 19th Century, Barlow, after his investigation into the causes of Infantile Scurvy said "prolonged deprivation of fresh vegetables or their equivalent is the most constant fact among the antecedents of the disease", and that uncooked meat and fresh milk are anti-scorbutic just like fresh vegetables although not to the same extent. "The further we get from a living food the less is the anti-scorbutic power. I suppose it will ultimately be found that raw milk is better than cooked milk". His treatment consisted of giving each child suffering from scurvy, plenty of fresh milk - a pint to each child of six months old - sieved potato (in the place of proprietary foods) and a tablespoonful of orange juice. Striking recoveries occurred in two to three days.

In 1914 there was an outbreak of Scurvy in the Hebrew Orphan Asylum<sup>(19b)</sup>, New York. The infants had been fed on cow's milk previously heated to 145°F. for thirty minutes, on the recommendation of a medical commission who had declared that, for infant feeding, heated milk was in every way equivalent to raw milk. Dr Hess, one of the consulting physicians, recommended the use of orange juice and the symptoms cleared up.

Vitamin C. is also found in milk; but unlike

A. and B. is unstable. It is gradually destroyed by heating milk above 50°C and quickly destroyed above 80°C. Heating milk at a high temperature for a short time is not so destructive as pasteurization. Rapid cooling assists in its preservation.

The amount in milk is subject to seasonal variations, probably on account of the amount in the fodder.

It is better to supplement the amount in cow's milk by giving orange or tomato or swede or grape juice, in that order of efficacy, to the infant.

#### (1h) VITAMIN D.

Following Gowland Hopkins' experiments with rats, Mellanby produced rickets in puppies, <sup>(21)</sup> by feeding them on separated milk, wheat, bread, linseed oil, yeast, orange juice and salt. He found that as little as  $\frac{1}{3}$  oz. of butter, daily, prevented it. Until 1926 it was thought that Vitamin A. was responsible for the anti-rachitic action of butter etc., as well as for the prevention of malnutrition and Xerophthalmia. In 1926, Rosenheim and Webster isolated a substance called ergosterol from irradiated cholesterol, which they believe to be pure Vitamin D. As little as  $\frac{1}{1000}$  milligram given daily to a rat, suffices to keep it free from rickets.

When fat soluble A. is removed by oxidation from butter/



butter or cod liver oil, they are still valuable in the treatment of rachitis. Also, the disease has been known to occur in children receiving large quantities of Vitamin A. The action has been attributed to a cholesterol-like substance which may be extracted from the livers of other fish also. It is also believed to be present in the skin and to be activated by ultra violet light. Cow's milk contains this vitamin only when the animals are exposed to sunlight or fed on green chlorophyll-containing vegetables.

#### VITAMIN E.

Knowledge of this vitamin is due chiefly to the work of Evans<sup>(21)</sup>. Experimenting on rats he found that feeding on skimmed milk powder, yeast and ferric citrate, produced sterility in both male and female. In the latter successful mating could occur; but after about eight days the foetus died and was resorbed.

Evans, Bishop and Sure have demonstrated its presence in wheat embryo, cottonseed oil, commercial olive oil, lettuce, meat and dry rolled oats.<sup>(20 & 21)</sup> These substances are rich in it. Milk fat contains it also, but in small quantities. The ordinary diet of human beings shews no deficiency in it. The only/

only point in which it is relevant to the artificial feeding of infants is contained in M. Collum's suggestion in 1927 that Vitamin E. is necessary for the correct assimilation of iron.<sup>(21)</sup>

Fresh raw cow's milk then, is entirely satisfactory as a source of Vitamins A. B. C. & D. and so far it has not been proved to be<sup>(13)</sup> lacking in E. Whether the milk should be given raw, boiled, whole or diluted, depends on many other factors.

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### ANATOMY AND PHYSIOLOGY.

The anatomy and physiology of the infant's digestive system differ in many ways from those of the adult. The most obvious anatomical difference is the lack of teeth. His food must, therefore, be liquid. Although Ptyalin is present in the salivary glands of the new born, it is found in such small amounts that although very small quantities of starch, such as may be found in weak barley water, can be digested, starch is not suitable before dentition at about six months.

THE STOMACH of the infant is more tubular and vertically placed <sup>(6a)</sup><sub>(8.)</sub> than that of the adult, owing to the slight development of the fundus. The muscular wall is relatively feeble. The anatomical capacity at different ages, estimated from post mortem investigations, was found to be:-

$1\frac{1}{2}$	oz.	at birth
2	"	" one month
$4\frac{1}{2}$	"	" three months
$5\frac{3}{4}$	"	" five to six months
9	"	" twelve months

But/

But X-Ray examination shews that during feeds a considerable quantity of milk passes into the Duodenum, so that the physiological capacity is greater than the actual stomach contents.

Holt<sup>(9)</sup> after a number of test feeds with breast fed infants gives the amount of one feed as:-

$\frac{5}{8}$	-	$1\frac{1}{2}$ oz.	in the	1st week
1	-	3 "	" "	2nd "
$1\frac{1}{2}$	-	4 "	" "	3rd "
$1\frac{1}{2}$	-	$4\frac{1}{2}$ "	" "	4th "
2	-	5 "	" "	5-7th "
$2\frac{1}{2}$	-	$5\frac{1}{2}$ "	" "	8-11th "
3	-	6 "	" "	4 month
$3\frac{1}{2}$	-	$6\frac{1}{2}$ "	" "	5 "
4	-	7 "	" "	6th "

#### EMPTYING OF THE STOMACH.

Morse & Talbot<sup>(10)</sup> found that stomach digestion lasts  $1\frac{1}{2}$  - 2 hours in breast fed infants and three hours in artificially fed babies, the duration depending partially upon the quantity taken and being delayed by the presence of hard clots. Free HCl as well as pepsin, rennin and lipase are found in the stomach at birth.

All these elements must be considered when fixing the amounts, modification and timing of the infants/



infant's feeds.

THE INTESTINE in the infant is relatively longer and the musculature feebler. This accounts for the greater tendency to flatulence in babies. At birth all the enzymes necessary to digestion are present so that the infant is equipped, however slightly, with all secretions necessary to digestion of protein fat and carbohydrate.

#### NORMAL DIGESTION OF MILK.

When milk enters the stomach the bulk of the protein is coagulated by rennin. The curd produced contains casein and some of the fat and salts from the whey, whereas the whey and its soluble contents of salts, sugar and lactalbumin pass into the duodenum. The curd is acted upon in the stomach by pepsin and converted into soluble peptones. If the curd is considerable in amount, it remains much longer in the stomach.

PROTEIN, After conversion into peptone is further acted upon by trypsin and erepsin of the small intestine and reduced to amino acids, in which form it is absorbed. Casein of cow's milk forms larger and harder curds than that of breast milk, but it has been shewn to be no less digestible. Feldman<sup>(1d)</sup> quotes experiments called the whey exchange experiments of/

of Ludwig Meyer. He interchanged whey and curd of human and cow's milk, and fed a number of normal infants as well as some recovering from enteritis. He found that the weight curves of those fed on human whey, containing either cow's or human curd were always better than those fed on cow's whey. Hence the important conclusion that bad effects resulting from cow's milk are not due to casein but to the whey. This observer obtained the same results when lactalbumin was removed from the whey, shewing that the irritating agent in cow's milk is the salt content which is three and a half times as great as that in human milk.

#### FAT.

A baby's body weight is composed of 12-12% fat, therefore, fat is extremely important. Also its high calorific value is a great source of heat to the infant. Further, fat contains the important accessory food factors A.D. and E.

It is possible to grow in length but to lose weight owing to the burning up of fat which may occur if in-sufficient fat is supplied to meet the demands for energy.

Fat digestion begins in the stomach. Lipase is capable of splitting fats into <sup>(11)</sup> fatty acids and glycerine; but for this process an alkaline medium is necessary so that digestion of fat does not go far until/



until the duodenum is reached. Fat is, however, freed from its condition of emulsification, in the stomach, by digestion of the protein envelope which causes the droplets to form an emulsion, and also, it is set free from the curds slowly so that only small doses reach the duodenum at one time. In the duodenum such fatty acids as have been split off, combine with the alkaline bases of the bile to form soaps. Of these soaps, some, potassium and sodium, are soluble and may be absorbed. Others, calcium and magnesium are insoluble and are found in considerable quantities in the lower bowel. The soaps also emulsify the unsplit fat and render it more easily digested by the stearopsin of pancreatic secretion.

It is possible that fat helps the absorption of minerals, especially calcium, so that a deficiency of fat results in deficient absorption of mineral salts. Excess on the other hand results in elimination by the bowel in the form of soaps of calcium and magnesium.<sup>(12)</sup>

CARBOHYDRATES are of three varieties, poly-, di- and mono-saccharides. It is only in the last form that they can be absorbed into the blood. To the first group belongs starch. The amylolytic ferment of the salivary glands acts on foods in the process of/

of chewing and the further digestion is finished in the small intestine. Of disaccarhides, lactose, found in human (7%) and cow's (5%) milk, and cane sugar, which is most usually added to make up the percentage in cow's milk, have each the appropriate enzyme in the small intestine. Lactose is converted into the monosaccarhides dextrose and laevoluse. Dextrose is absorbed straight into the blood stream; but galactose and laevulose are converted in the liver into glycogen for storage, and only transformed into dextrose in the blood stream when necessary.

SALTS AND ACCESSORIES are essential to growth and to the vital processes of the body. They do not contribute to the caloric needs. The exact effect on an infant of the lack of any one of them is not known<sup>(7)</sup>. The use of some of them has been found e.g. calcium, magnesium and phosphorus are essential for bone formation. The chlorides are needed for HCl of gastric juice and calcium and sodium have an influence on the irritability of the nervous system, the former inhibiting it and the latter increasing it. Iron is necessary for haemoglobin and iodine appears to be connected with normal endocrine function. The other accessories called vitamines are found in both human and fresh cow's milk.

WATER./



WATER.

An infant requires five times as much water per unit of body weight as an adult, owing to the greater amount in its tissues, - 70% as against 60% in the adult<sup>(1e)</sup>, and to its more rapid metabolism. The normal daily requirements of an infant are  $2\frac{1}{2}$  oz. of water per lb. of body weight<sup>(14)</sup>. This accounts for the rapid emaciation which occurs in cases of diarrhoea.

EXCRETION.

The infants' excretory organs are the same as those of the adult, namely skin, lungs, bowel and kidneys, but the relative proportion of waste products differs from that of the adult.

The end products of digestion are, in health, fully oxidized. They are, for the most part, urea, CO<sub>2</sub> and water. CO<sub>2</sub><sup>m</sup> are the end products of fats and carbohydrates. Urea is the end product of protein digestion.

From Forster's experiment<sup>m</sup> in 1877, it was found that infants lose twice as much CO<sub>2</sub> per unit of body weight as adults.<sup>(1a)</sup>

When acid products other than CO<sub>2</sub> are formed in the system, alkaline bases must be found to neutralize them. Ammonium is the base so used, consequently a certain proportion of nitrogen is excreted as ammonium/

ammonium salts. Pritchard gives the difference (12a) between infant and adult excretion of nitrogen as:-

Total Nitrogen in urine	Adults%	Infants %
As Urea	80-90%	69.%
" Uric Acid	1.53%	5.4%
" Ammonia	4.2%	8.5%
" Other N. bodies	4.11%	17.1%

#### METABOLISM AND DYSFUNCTIONS MET BY MODIFICATIONS.

The metabolism of the infant is much more rapid than that of the adult because:-

(1) The child is growing and requires extra calories over and above those required by adults for ordinary wear and tear. (1f)

(2) The surface area of the body is relatively large.

The physiological requirements of the healthy infant are obtained by:- (1g.)

(1) Estimation from the amount required for a healthy Breast Fed Child.

(2) Calculation from the body weight.

The/



The latter must be based upon:-

- (1) The basal metabolism, i.e. the amount of heat produced by a fasting infant at rest. These two states being incompatible, it is estimated during deep sleep even after a feed.
- (2) The heat used up by muscular activity which of course varies with age and condition; such as crying etc.
- (3) The growth quotient. This diminishes with age after three months.
- (4) Loss by excretion.

Experiments made by Benedict & Talbot shew the following figures for basal metabolism at different ages<sup>(15)</sup>.

Age of Child.	Basal Metabolism in calories per Kg. per day.
0 - 12 hours	38.
12 hrs. - 2 weeks	42.
2 " - 2 months	57.
6 - 12 "	59.
1 year.	58.

Thus/

Thus we see that the basal metabolism does not increase from four months to one year:-

(1) Feldman estimates the total Caloric (lg) requirements:-			(2) G.B. Fleming (16) estimates them as:-		
B.M.	60 <sup>c</sup>	per Kg.	B.M.	55 <sup>c</sup>	per Kg.
Muscular activity.	30	" "	Growth	5	" "
Growth	9	" "	Muscular activity.	35	" "
Excreta	11	" "	Excreta	5	" "
TOTAL 110 " "			TOTAL 100 " "		

Translated into pounds, Thomson<sup>(8a)</sup> agrees with Dennett<sup>(13)</sup> that the caloric requirements are 40-55 calories per pound of body weight.

Human milk and cow's milk each produce twenty calories per pound, one ounce of sugar 110 calories.

I wish, next, to discuss briefly the giving of different modifications of cow's milk, and the various dysfunctions which render modification necessary.

Budin<sup>(17)</sup> used whole sterilized milk with complete success in young infants, even from birth; but he makes the following remark "infants may or may/



may or may not be healthy and in the latter case their digestive tube needs judicious treatment ..... My custom is to prescribe pure milk, and any departure from this is determined upon only by careful observation".

Thompson<sup>(8b)</sup> agrees with this provided the infant is healthy. From personal observation also I know this to be true. Eric Pritchard<sup>(7)</sup> on the other hand considers this entirely contrary to physiology, although he suggests that some of the successes are due to the presence in small quantities of certain accessories, the effects of which may be lost on dilution. He advocates the humanizing of all substitute foods, and, as a plea for sound physiological methods points out the fact that in the human infant, as growth becomes less active, protein diminishes in its natural food, and as work increases so does the sugar content.

In cow's milk, on the other hand, there is a fall in the amount of milk and a rise in the protein percentage. ?

Most methods of modifying cow's milk are therefore unphysiological as they increase the proportion of protein, by diminishing the dilution, and lessen the sugar content as the infant passes from birth to twelve months.

FAT INTOLERANCE./

FAT INTOLERANCE.

At a meeting of the Maternity and Child Welfare group of the Society of Medical Officers of Health<sup>(18)</sup> a discussion on the fat needs and on the choice of fat took place. Most observers agree that fat intolerance is produced if cream is used to make up modified cow's milk to human standard. The general opinion at the above meeting was that pure cod liver oil was the simplest and best substitute, providing vitamins A. & D.

It may be that part of the success with citrated milk may be due to the increased buffer content allowing lipase a longer period of action.

Although Faber<sup>(11)</sup> gives exactly the opposite reason for the improvement in fat tolerance when acidified milk is used.

The reason for which citrated milk is given is however, that when sodium citrate is added to cow's milk, precipitation of the calcium caseinate occurs and so prevents curdling by rennin. Citration then really belongs to the group of modifications which aim at rendering casein more digestible. To this group also belong dilution, and boiling.

I propose to discuss fully the different modifications in another section and to go into detail about the preparation of different forms.

-----



COMPOSITION AND PRODUCTION OF COW'S MILK.

I have given, in the introduction, the percentage composition of cow's milk, compared with that of human milk.

It is:-

	Caseinogen	Lactalbumin	Total Protein	Fat	Carbohydrate	Ash	Water
Human	1	.5	1.5	3.5	7	.2	86.3
Cow	3	.5	3.5	4	5	.72	83.3

The obvious differences have already been discussed, that is, that cow's milk has three times as much caseinogen and three and a half times as much ash as human milk. If this were all, modification of cow's milk would be a simple affair. Unfortunately for the infant the chemical composition of every element of cow's milk except lactose, which is the same in every animal, is different from that of human milk.

THE CASEINOGEN of cow's milk, when digested yields different proportions of the amino acids from the caseinogen of breast milk, so that even if cow's milk be diluted until the gross proportions of caseinogen are/



are the same as in human milk, it has still a difference in quality. Moreover, it forms a larger and tougher curd and when precipitated by rennin.

WHEY PROTEIN although found in the same percentage in both milks, in breast milk is richer in lysin and tryptophane, two of the essential amino acids. Included in lactalbumin is a small quantity of lactoglobulin, which, it is thought, carries the immune bodies which protect breast-fed infants against disease. The lactoglobulin of cow's milk protects the calf but does not convey immune bodies to the human infant.

The protein contents of milk from different species are shown to be different by immunological methods also.

#### FAT.

The fat in human milk has a lower melting point (18) than that of cow's milk because it contains more oleic acid and the fat globules are smaller. For these reasons it is more easily digested. Another point of great interest and importance is the presence of lecethin in higher percentage in human milk than in that of <sup>the</sup> cow. Lecethin is needed chiefly for brain and nerve tissue and is therefore required in greater quantities for the human infant than for the calf.

#### SALTS./



SALTS.

The total quantity of salts in cow's milk is three and a half times that of breast milk and Meyer's experiments<sup>(1d)</sup> have shown that the salts are the cause of indigestion rather than the protein. An analysis of the ash, however, shows the salts to be:-<sup>(12b)</sup>

	K <sub>2</sub> O	Na <sub>2</sub> O	CaO	MgO	Fe <sub>2</sub> O <sub>3</sub>	P <sub>2</sub> O <sub>5</sub>	Cl	Total
Human	•08	•02	•03	•006	•0005	•046	•043	•21
Cow	•17	•05	•2	•02	•001	•24	•095	•7

so that even, if given undiluted, cow's milk is deficient in iron, and if diluted to half strength phosphorus is in excess.

I propose to discuss the modification elsewhere.

PRODUCTION.

The production<sup>(3)</sup> of cow's milk includes everything which affects the milk in its transit from the cow to the consumer.

Legislation in the milk trade has taken two forms:-

- (1) health and sanitary control,
- (2) control by chemical analysis for adulteration.

Group/

Group I has been effected by the Contagious Diseases (Animals) Acts, 1878 and 1886, and the various Daries Cowsheds and Milkshops Orders from 1885-1926, which all aim at producing a clean and wholesome milk supply, in requiring cleanliness of the cows, buildings, milkers, utensils and churns, and by preventing the containers from being opened in transit.

The laws applying to Group 2 include the Sale of Foods and Drugs Acts from 1875 onwards, and the Sale of Milk regulations 1901. The object of these acts was to fix a standard of butter fat and of solids not fat and to prevent adulteration by addition or subtraction, so that the fluid reaching the consumer should be genuine milk, in the proportions in which it left the cow.

Even genuine, unadulterated cow's milk is subject to variations in the breed of cow, the season, the stage of lactation and the vitamin content.

Thus Jersey cows yield a smaller quantity of milk than Holsteins; but the former give a milk containing 5% fat and the latter milk of 3.5% fat. Also, a seasonal variation in fat occurs. It is lower in May, June and July, and higher from October to January.  
(22)

Cow's milk differs from human milk in this important respect also; it gets less in quantity and richer in protein as lactation proceeds. The Vitamin/



Vitamin content varies with the animal's food and with its exposure to sunlight. For all those reasons milk from a herd is of a more uniform quality than that from one cow.

In order that cow's milk may be more nearly suitable for infant feeding, great care must be taken in the handling of it.

The standard of cleanliness is measured in bacteria, per cc. The sources of bacterial contamination are diseased animals, dirty animals, diseased milkers, dirty milkers, dirty surroundings, utensils and methods of transport, exposure in the shops and want of care in the home. Legislation and adequate supervision can prevent all of these, but the last, without demanding great outlay on the part of the producer. American experiments shewed that in ninety three samples of milk from five farms, the bacterial count was reduced from an average of 87,391 per cc. to an average of 4,602 per cc. by the following simple measures. (1) Using sterilized vessels, (2) milking clean cows, particularly udders and teats, and (3) the use of the small topped pail, without altering anything else (22).

The ideals to be aimed at, in the seat of production/

production, are that the building should be kept clean and free from manure, and properly lighted and ventilated; that the cows should be cleaned and groomed regularly and their udders wiped with a clean damp cloth before milking; that the milkers should wear overalls and caps, and wash their hands before milking; that the first few spurts of milk should be discarded to clear the teats of any bacteria which may be there; that all vessels should be sterilized by steam before use and that small topped pails should be used; and finally, that after milking, the milk should be strained through a sterilized cloth and immediately cooled to 5°F. above the temperature of the available water supply.<sup>(3a)</sup>

The 1926, Milk and Dairies Order lays down this last condition,<sup>(3a)</sup> the importance of which may be seen from the fact that even in a high grade milk with a bacterial count of only 3,000 per cc. after twenty four hours at a temperature of 68°C. the count may rise to 450,000.

The bacteria are for the most part non-pathogenic, but the bacterial count in untreated milk is an indication of the freshness and care in handling.

Since 1918, efforts have been made to produce higher grades<sup>(3b)</sup> of milk, by the granting of licences to producers to demand higher prices for milk of a greater hygienic quality.

The/



The Official Grades are:-

A. CERTIFIED. The requirements of this grade are:-

- (1) Herd to be tuberculin tested every six months.
- (2) " " " completely isolated from all other cattle.
- (3) Output to be bottled on the farm immediately after production.
- (4) Every bottle to be sealed completely by suitable disc and cap.
- (5) Purchaser to receive milk thus sealed.
- (6) Bacterial standards, maximum 30,000 per cc. and none of the coliform group in 1/10 cc.
- (7) No treatment by heat permitted.

B. GRADE A. t.t.

- (1 & 2) As in "A".
- (3) Concerns retailing.
- (4) Unless bottled and sealed on the farm to be consigned in unventilated sealed containers.
- (5) Bacterial standards 200,000 per cc. and no coli organisms in 1/100 cc.
- (6) As in 7 "A".

C. GRADE A.

- (1) Herd to be subject to clinical examination every three months.
- (2) Cows to be kept free from all other cows in milk.
- (3,4 & 5) As in Grade A. t.t.
- (6) No heat to be applied unless a pasteurizing licence is obtained.

D. GRADE A. (pasteurized).

Requirements as for Grade A. except:-

- (1) Pasteurization permitted by recognized process.
- (2) Bacterial standards maximum 30,000 per cc. and no coli organisms in 1/10 cc.

E. PASTEURIZED MILK.

- (1) Pasteurization to be by the "holding" method, i.e. retention for at least half an hour between 145°F. and 150°F., and the milk to be cooled immediately to a Temperature of not more than 55°F.
- (2) No treatment more than once by heat.
- (3) Recognised plant and equipment to be used.
- (4) Bacterial standards maximum 100,000 per cc.

The/



The standards of fat and of solids not fat, are the same in graded Milk as in ordinary market milk, viz. 3% fat and 8.5% other solids.

There are brands of fresh milk sold, which have unofficial descriptions. They are "Jersey" Milk and "Nursery" Milk.<sup>(3b)</sup> The former is produced by the English Jersey Breeders' Dairies Ltd., and is obtained from Tuberculin Tested Jersey Cows, pasteurized and sold at a higher price than ordinary milk. "Nursery" milk, on the other hand, is usually selected by the dairyman from among his supplies, as the cleanest and richest, and is also sold at a higher price.

There is still another form in which fresh milk may be sold, viz. sterilized. Sterilization of milk may be accomplished by heat or by the action of ultra-violet radiation. Truly to sterilize milk by heat requires that it should be super heated, in order to kill the spores of spore bearing organisms. This process destroys the milk and spoils the flavour.<sup>(Ix)</sup> What is usually spoken of as sterilized is achieved by raising the milk, after homogenizing the fat globules to 100°C. or 212°F, for from twenty to thirty minutes.<sup>(3b)</sup> This is done after bottling. It has considerable keeping properties and may be used, if unopened and kept cool, two or three days after distribution.

Ultra/

Ultra Violet Radiation <sup>(Ix)</sup> destroys bacteria and also enhances the ante-rachitic properties. This would appear to be the ideal method; but is not yet practicable.

The value of the various official grades is obvious and needs no comment.

The sale of "Nursery" milk may lead to exploitation of the unwary consumer as there is no official backing to the claims of the dairyman.

Authorities are divided on the subject of pasteurization on a large scale.

Its advantages are:-

- (1) Protection from infection by pathogenic organisms which may have found their way into the milk.
- (2) Increase in the keeping quality of the milk.

The objections to it are:-

- (1) Tendency of the milk, when kept to putrefy rather than turn sour.
- (2) Pasteurization may be used to hide dirty production and may lead to slipshod methods.
- (3) Milk which has not been sold may be pasteurized and sold as fresh.
- (4) Vitamin C. may be destroyed by the "holding" method. This is relatively unimportant as the ante-scorbutic vitamins can always be given by orange juice.
- (5) The milk may be reheated in the homes.
- (6) Unless kept at a low temperature the undestroyed spores will grow and multiply.

STERILIZATION./



### STERILIZATION VERSUS PASTEURIZATION.

Sterilization, before selling, has <sup>this</sup> great advantage that the fat globules are homogenized and more digestible, and the bacteria are killed. But, on the other hand, one can never be quite sure how ignorant people will treat milk that was clean and wholesome before it reached their homes.

Pasteurizing by boiling water round the milk, contained in a jug or jar, for twenty to thirty minutes is also uncertain in the hands of ignorant people. Moreover, it is not definitely established that the tubercle bacillus is destroyed by this procedure.

Personally, I should advise ordinary boiling of the day's milk supply, in the homes, although I have used milk, sterilized before selling, in infant feeding, with success. It has the advantage of simplicity. It renders the milk more easily digested and if only raised to boiling point for a short while (two or three minutes) does not destroy Vitamin C. while it does kill all the pathogenic organisms.

Of course the ideal is that everyone should receive clean raw milk of the Certified or Grade A. t.t. type. Whether the milk should be administered raw to infants, comes outside the scope of the section; /

section; but I have tried to set forth the conflicting ideas on the subject of providing the next best thing.

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the rules applying to the daily amounts of milk are the same as those for boiled milk. It is customary to add 1-2 gr. of sodium citrate per ounce of cow's milk.

Calculation of amount required.

The protein requirements of a normal infant are 1.5 gm. per kilo of body weight. This is supplied by 3 oz. of human milk or  $1\frac{3}{4}$  oz. of cow's milk per lb. of body weight.

A baby needs  $2\frac{1}{2}$  oz. of water per lb. The exponents of whole milk feeding have ~~been~~ decided that it is better to ignore the excess of protein, which it has been proved, can be digested, and not to dilute those substances which are already present in smaller quantities in cow's milk than in breast milk. Following this principle the infant is given  $2\frac{1}{2}$  oz. of cow's milk per lb. of body weight.

An average infant weighing 7 lbs. at 14 days, then, would require  $7" \times 2\frac{1}{2}" = 17\frac{1}{2}$  oz. of milk per diem. Divided into seven feeds, six at three hourly intervals from six a.m. to nine p.m. and one night feed at two a.m. this would work out at  $2\frac{1}{2}$  oz. at each feed. The same infant at six months, having doubled its weight would require  $14" \times 2\frac{1}{2}" = 35$  oz. divided now into five feeds in the day, at three hourly intervals from seven a.m. to seven p.m.

This/



This also accords with the Physiological capacity set forth in the section on Anatomy and Physiology.

In all whole milk feeds there is excess of protein and salts. To deal with the excess must throw a great strain on the organs of digestion and excretion. The results of this feeding, although perfectly satisfactory at the time, in many cases may be further reaching and lay the foundation stone for certain digestive troubles of later life.<sup>(7)</sup>

(2). Diluted Sweet Milk.

Percentage feeding.

This type of modification definitely aims at "humanization" of cow's milk. It is based on the methods of Meigs and of Morgan Rotch. The former method, followed by Truby King consists of allowing milk to stand for several hours, and dipping off the top quarter. When this is diluted with the same quantity of water the protein is reduced by half and the fat remains constant. Sugar is added to bring the percentage up to human (7%) standard. Truby King<sup>(5)</sup> gives the following recipe for humanizing milk:-

'Top milk'	13 oz.
Lime water	$1\frac{1}{2}$ "
Sugar of milk	$1\frac{1}{2}$ "
Boiled water	$15\frac{1}{2}$ "

He/

He gives these instructions for obtaining 'top milk'.

"For  $1\frac{1}{2}$  pints of humanized milk set a quart of new milk for seven hours. Then dip off the top 13 oz. Dissolve the sugar of milk and mix the ingredients. Heat to  $155^{\circ}\text{F}$ , cool rapidly and keep cool. This mixture certainly reduces the protein to the proportions of human milk; but unfortunately it reduces the lactalbumin to half the human standard. To meet this difficulty Truby King and others, following Morgan Rotch, use whey as a diluent of cow's milk.

This method is even more complicated. Whey is produced by curdling milk with rennet, breaking up the clot and straining off the fluid. The whey of whole milk has the following composition.

Casein 0.    Lactalbumin .5.    Fat 3.5.    Lactose 5.

The whey of skimmed milk has .1% fat, but has the same percentage of other ingredients.

Starting with either of these as a basis, cream, sugar, whole milk or skimmed milk can be added to make up the desired percentage, e.g. if it be desired to prescribe a food containing 1.0% caseinogen, .5% lactalbumin and 3.5% fat. Milk containing 3% caseinogen must constitute one third of the mixture and whey two thirds.

Truby King gives this recipe. (5).

Top/





Top Milk	10 oz.
Whey	12 "
Lime Water	1½ "
Sugar of Milk	1 "
Boiled Water	6½ "

His instructions for this recipe are the same for the 'top milk' only in this case 10 oz. are dipped off. He makes the whey from 18 oz. of the remainder as follows. "Put the 18 oz. in a jug. Keep a dairy thermometer standing in the milk and heat to 105°F by placing the jug in a sauce pan of hot water. Stir in thoroughly a teaspoonful of best rennet extract; allow to stand for three minutes, when a firm curd should have formed. Break up thoroughly. Heat to 155°F for five minutes to kill the rennet. Pour off the whey, add it to the top milk and add the other ingredients. Heat the jug of humanized milk to 155°F for ten minutes. Cool rapidly in running cold water."

I have given these two recipes at some length in order to demonstrate their extremely complicated nature. There can be no question that in certain cases such extreme accuracy has been found necessary but it must never be forgotten that no amount of scientific manipulation will truly humanize cow's milk, and that such complicated measures are only suitable/

suitable for institutions where a skilled staff is available. As Eric Pritchard says, you may render the milk nearly human and supply the vitamins; but "what of the iron, iodides and many other essential factors of nutrition?"<sup>(7)</sup>.

#### Caloric Feeding.

Paterson and Forest head a chapter on artificial feeding<sup>(14)</sup> with a quotation from Joseph Brennemann. It is "The essential problem of the whole of artificial feeding is to modify cow's milk so that the infant will thrive on it as well as it does on breast milk". They follow this by saying "This is not accomplished necessarily by making cow's milk approximate to breast milk in its composition; but the aim is to make it act as adequately as Mother's milk".

This brings me to the second method of estimating the physiological requirements of infants, mentioned in the section on Anatomy and Physiology, viz. calculation from the body weight based on the metabolic needs.

(13a)  
These are:-

- |     |                                  |                 |
|-----|----------------------------------|-----------------|
| (1) | For fat infants over four months | 40-50 calories. |
| (2) | " average " under " "            |                 |
|     | and moderately thin infants      |                 |
|     | of any age.                      | 50-55 "         |
| (3) | " emaciated infants              | 60-65 "         |

As I pointed out above, the infant needs at least/



least 1.5 gm. of protein per kilo of body weight. This is supplied by  $1\frac{3}{4}$  oz. of cow's milk. The infant also needs  $2\frac{1}{2}$  oz. of fluid per lb. of body weight.

Take the case of an infant one month old, weighing eight lbs.

It requires:-	a total of 8 x 50	= 400c
	8 x $1\frac{3}{4}$ oz. milk = 14 x 20	= 280c
		<hr/>
	Deficiency	120c

This may be supplied by adding:-

One level teaspoonful of sugar to each feed,

7 x 20	= 140c
--------	--------

Total	420c
-------	------

The infant also needs 8 x  $2\frac{1}{2}$  oz. fluid = 20 oz.

To make up this child's feeds for one day require:-

Whole Milk	14 oz.
Sugar	7 teaspoonfuls.
Boiled Water	6 oz.

This child requires seven feeds given at three hourly intervals of 3 oz. each.

Here is another example. A fat infant, five months old, weighing 15 lbs.

Its/

Its total caloric needs are	15 x 40	=	620c
" protein requirements are	15 x $1\frac{3}{4}$	=	26 oz. cow's milk.
" fluid	" " 15 x $2\frac{1}{2}$	=	37 oz.
26 oz. of cow's milk supply	26 x 20	=	520c.
Half teaspoonful sugar in six feeds gives	6 x 10	=	60c.
	Total	=	580c.
	Deficiency	=	40c.
This may be made up by giving 4 oz. of skimmed cow's milk	4 x 11	=	44c.
	Total		624c.

A suitable diet for this infant for one day would be:-

Cow's milk	26 oz.
Skimmed "	4 "
Sugar	3 teaspoonsful.
Water	7 oz.

This would be divided into six feeds of 6 oz. each, which also satisfies the physiological capacity of the stomach.

ACIDIFIED MILK. may be produced in two ways:-

- (1) The milk is soured by the addition of some lactic acid producing organism. After sterilization, the milk is inoculated and incubated for eight hours. The curd is broken up and rubbed/



rubbed through a sieve. It is then given in suitable dilutions or whole. Skimmed milk is used where fat curds are present in the stools. Sugar may be added according to the requirements.

- (2) Boil the amount required and when cold, add drop by drop a teaspoonful of lactic acid for every pint of milk. Stir all the while.

The literature on the subject of acidified milk is interesting because it is so contradictory. Faber<sup>(11)</sup> advocates it on the grounds that in reducing the buffer value, it increases the action of gastric lipase. He uses the second method of preparation as physiological feeding for healthy as well as sick infants, but uses 1/10 N HCl in the proportion of one of acid to three of milk, on the grounds of cheapness.

<sup>(23)</sup>  
Cassie & Cox favour its use only in cases of enteritis and purely on its biological action. They consider that the addition of acid is quite unnecessary and shew that there is little difficulty in obtaining sufficient secretion of HCl to meet the need of suitable pH concentration for gastric digestion, in infancy. They, therefore, use only the first method of preparation. Stephen & Walker<sup>(24)</sup> commend its use ~~altogether~~, because they think that the difficulty in digesting cow's milk is entirely due/

due to its high "buffer" content, so that the HCl of gastric juice never reaches the pH required for full peptic digestion. They suggest that HCl is the most logical acid to use; but that it tends to lower the alkali reserve of the body. Lactic acid, on the other hand, is one of the natural products of metabolism and fully oxidized in the tissues. Also, at the concentration necessary, only lactic acid-forming organisms can flourish.

They prepare the milk by the second method; but use  $1\frac{1}{2}$  drachms of lactic acid to the quart. They do not say whether whole or diluted milk is used; but mention the addition of sugar according to the individual needs of each case.

Acidified milk has, as its objective, that salient of the battlefield, behind which the salts are entrenched. In overcoming the buffer excess there is always the possibility of causing acidosis. This has to be kept constantly in view.

Stephen & Walker, following Marriott, the American protagonist of lactic acid feeding look upon it as a physiological method, and not only as a therapeutic measure.

There are no figures for out-patients, or better still, infant welfare clinics. These latter writers found the results very satisfactory in sick infants treated in hospital; but the test of infant feeding must/



must be the results obtained by the ignorant mother in her own home, without constant supervision.

As a therapeutic measure, I have seen it used very successfully, at an infant welfare centre. It was prepared by the mothers after a demonstration from a nurse.

In normal infants it would appear to be a simple matter to decrease the acid gradually, near weaning time, in order to accustom their digestive organs to dealing with a more complicated diet.

The addition of acid to milk in no way alters its caloric value so that the question of amounts and times of feeding is answered by those rules which apply to other modifications of cow's milk.

#### TECHNIQUE OF ARTIFICIAL FEEDING.

I have already referred to the need for intelligent management of the feeding, in my introduction. Apart from the choice of food and its preparation, such details as the bottle, teats, position in feeding etc., contribute largely to success or failure.

Bottle. The choice lies between the boat-shaped bottle, open at both ends, and the type of bottle used in many home sterilizers. This latter has only one opening and has sloping shoulders and a rounded/

rounded bottom inside.

In the former the rubber teat closes one end and a rubber valve the other. It is only suitable for giving the feeds from and not for preparation of them. The other type is usually sold in sets, so that all the feeds for the day may be prepared together. I prefer the boat shaped bottle because it can be flushed through with water immediately after use and kept clean without the use of a bottle brush.

Teats. The teat should allow the milk to drip from it at the rate of a drop per second. Sucking from it ought always to require some little effort on the part of the infant; but should not be so difficult as to exhaust him.

Hours of Feeding. No hard and fast rule can be laid down on this point. From the point of view of convenience, four hourly feeds are the best; but not every infant can stand this and it is not always possible to combine the caloric requirements with satisfaction of the physiological capacity, with so few feeds in twenty four hours.

Dennett recommends six three-hourly feeds from 6 a.m. to 10 p.m. with one night feed at 2 a.m. up to three or four months or 12 lbs. weight. Then he omits the 2 a.m. feed and gives six feeds up to 15 lbs. weight. After this, he gives five four-hourly/



hourly feeds until twelve months.<sup>(13a)</sup>.

Position of bottle and infant. The infant should be supported comfortably on the nurse's lap, almost in an upright position against her arm, so that swallowed air may be eructated easily.

The bottle should be held so that the teat and neck are full, to prevent air sucking, and with the end of the teat sufficiently far away from the back of the mouth to prevent coughing and spluttering. Also, a certain "pull" against the infant should be maintained, in order to stimulate strong suction which helps to develop the jaws. After the feed the baby must be held upright with a certain amount of pressure over the abdomen, to help eructation of flatus, before he is laid down to sleep.

All these points contribute materially to the success of artificial feeding.

The importance of the actual giving of the feeds is exemplified in the following case.

Baby M.P., a healthy full time child, was unfortunately, bottle fed from birth. The feeds consisted of diluted sterilized milk. The mother complained that he vomited and I observed that he was losing weight rapidly. Unless something were done quickly, he would die. A nurse was provided by the Public Health Authority and sent daily to the house, for continuous nursing. I must explain that medically speaking, she was untrained. Her only experience had been gleaned in the corporation maternity/

maternity wards; but she was intelligent and did what she was told. From the time she began nursing him the baby never vomited and steadily gained in weight. There was no change in his diet or surroundings. The only change was in the way in which the feeds were given.

I have tried to give an impartial survey of the different ways of offering fresh cow's milk to an infant.

Each has been and is now used in their feeding. The success of any modification in a certain number of cases is no criterion of its appropriateness to the needs of all infants.

There is one point upon which all authorities agree, and it is, that an infant will not thrive until he is receiving the number of calories suitable to his weight, whatever the modification may be.

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SUMMARY AND CONCLUSION.

- (1) As a substitute for breast feeding, cow's milk is the best food that has yet been found, from the point of view of economy and adaptability.
  - (2) For infant feeding, definite standards in the composition and in the cleanliness of production are essential.
  - (3) Fresh cow's milk, even whole, is perfectly digestible by the normal infant, even under three months old; but in certain cases of impaired or feeble digestion some sort of modification is necessary.
  - (4) An exact way of "humanizing" cow's milk has not yet been devised; but good results are found from many modifications, viz. boiling, citrating, diluting and acidifying.
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